INSTRUCTIONAL OBJECTIVES IN BIOLOGY

(WITH ILLUSTRATIVE EXAMPLES)

J. P. AGARWAL
READER

DEPARTMENT OF MEASUREMENT, EVALUATION, SURVEY
AND DATA PROCESSING
NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING
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PREFACE

We have all along been envisaging an improvement in the process and programme of evaluation so as to make it a valid and reliable measure of pupil growth as well as a powerful instrument of improving the curriculum transaction in the class-room. Instructional objectives are the undisputed starting points in this venture. They are the reference points for both teaching and testing. While teaching-learning experiences are devised and organised with a view to realizing the predetermined objectives, the testing situations are created and used for judging the extent of achievement of the stated objectives on the part of the learners.

Instructional objectives, as such, are of much functional importance both for teaching and testing. Therefore it was felt purposeful to develop the present brochure presenting the theoritical basis of instructional objectives and their taxonomies in the cognitive, affective and psychomotor domains. Besides this, each objective of the cognitive domain is further elaborated in terms of behavioural objectives or specifications. Sample questions of various forms are framed to make explicit the meaning and intent of each specification. This would help to both teachers and evaluators including curriculum framers, textbook writers and educational administrators the tangible targets to achieve and assess in respect of each the stated objectives and its

specifications.

The sample questions representing each specification were developed in a workshop titled, "Development of Illustrative Questions for Testing Various Specifications of the Instructional Objectives" held at the NIE Campus w.e.f. January 22-25, 1990. I am thankful to these curriculum and evaluation experts including the subject experts, pedagogues and practising teachers for their significant contribution. The material so developed was further reviewed in the department and brought up in the present form.

I owe my gratitude to Dr. P.M. Patel, Head, Department of Measurement, Evaluation, Survey and Data Processing, NCERT, New Delhi for his valuable suggestions given time to time.

My thanks are also due to Dr. Avtar Singh, Dr. P.M. Gupta and Dr.(Miss) Santosh Sharma for guiding and supervising this work.

I am thankful to Shri Har Bhagwan, Section Officer, DME&SDP for providing all possible facilities required to bring this brochure in the present form. I also express my sincere thanks to Shri Jag Mohan Kapur, A.F.C. for assisting me in the smooth conduct of this workshop. I am also thankful to Mr. Mangal Dass, PA, Mrs. Mridula Gautam, Mrs. Sneh Lata Dhami,

and Mr. D.S. Mandral, Typists and Mr. Braham Singh, Gestetner Operator for helping me to bring this material in this form.

I hope practising teachers and professional evaluators would make use of this material in implementing the measures of examination reform, specially in making evaluation in Science Objective-based, formative and effective. Their comments and suggestions for the further improvement of this brochure are earnestly solicited and will be thankfully received.

J.P. AGARWAL
READER
DESSIDE, NCERT

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NATURE, PURPOSE AND DERIVATION OF INSTRUCTIONAL OBJECTIVES

1.0 INTRODUCTION:

Public examinations exert an overwhelming influence on the class-room instruction of schools and colleges in almost all countries. Both school and college teachers as well as educational planners and administrators are aware this fact. At places, the instructional programme gets limited to providing solution to examination questions of the previous years. This makes teaching examination-oriented and leads to emphasize rote memorization of the content elements. In other words, acquisition, retention and reproduction of limited number of terms, facts, methods, trends, sequences, concepts, principles, generalisations and themes become the main aim of education at the cost of several other objectives significant enough for providing an indispensable foundation for adult life and work in an increasingly scientific and technological age.

How to overcome this back-lash effect of examinations? It would be most feasible and practicable that the educational outcomes are formulated after having considere its philosophical, social, psychological, educational and ecological implications and that the objectives of teachin and those of testing largely overlap. This needs an objective based teaching-learning programme with an in-built element of continuous evaluation involving formative diagnostic and summative evaluation, and also provision of

*J.P. AGARWAL, READER, D.M.E.S. & D.P., N.C.E.R.T., NEW DELHI-110016.

feed-back. This only can make the teaching effective, efficient and purposeful. In such a system of education, instructional objectives not only occupy the central positi but guide and control the entire process of education, i.e. the content, methods, teaching-aids, pupil motivation, evaluation tools and feed-back. For this purpose, it would be in fitness of things, if one gets familiar with the nature, purposes of instructional (or educational) objectiv and the criteria involved in their derivation.

2.0 NATURE OF INSTRUCTIONAL OBJECTIVES

What is an (educational or instructional) objective? According to N.K.Upasani "Objectives are the policy statements of education". But E.Harper prefers to define them as "statements of expected results". This means that an objective states the way in which the pupils will be different at the end of teaching of a particular topic, unit, or course from what they were at the beginning. This differenc is often, in the form of overt behaviour and so can be measured with the help of appropriate tools and techniques. Thus, the instructional or educational objectives are the "changes in pupil behaviours" or "behavioural outcomes" desired to develop directly or indirectly as a result of teaching. As these changes in pupils 'behaviour are deliberately desired for development in the best interest of the society as well as of the learners, they carry a value of 'goodness' or 'usefulness'. This reflects 'normative nature' of the instructional objectives.

Thus, an instructional objective is a complete statement which states:

(1) a desirable behaviour for development in accordan with values and ideals of the society rather than value or ideal,

(2) a pupil's overt behaviour arising at the end of teaching-learning process rather than the learnin experience,

(3) a product of learning or a learning outcome instead of the process of learning (teacher-pupil activities),

(4) a pupil's performance or his terminal behaviour instead of the teacher's performance or his metho of teaching,

(5) a change in pupil's behaviour rather than the learning of content and materials bringing about this change.

In essence, an instructional (or educational) objecti represents a desirable change in a pupil's overt behaviour related with the product of learning which is usually termi nal, meaningful, attainable and measurable. It provides direction for the pupil growth and controls the entire process of teaching including content, methods, materials, motivations and evaluation. There is no need to confuse wi several terms in use, like aims, purposes, goals, intentions behavioural outcomes, general and specific objectives, long range and short-range objectives, direct and indirect

(vicarious) objectives which carry almost always one and the same meaning. However, an objective may vary in the degree of generality while stating them at various levels, e.g., elementary-education level, class-wise subject level, unit level, teaching-topic level etc. At the lowest level, i.e., at the teaching topic level objectives are stated in more specific terms, both in terms of change in behaviour as well as the content area sampled, but they gradually merge into the higher level objectives. Thus the former are just extensions of the latter.

3.0 PURPOSES OF FORMULATING INSTRUCTIONAL OBJECTIVES:

Instructional objectives and expected learning outcomes are required for the purpose of communication to teachers, pupils and examiners in order to clarify them what is expected of the student at the end of a given period of study (E. Harper). This communication, on one hand, provides guidance and control over the entire teaching-learning programme with an element of feed-back to offer direction of pupil growth, and on the other hand, develops an active student involvement in learning by making them aware of 'what is expected of them'. Besides these points, formulation of instructional objectives lead to develop certain desired abilities, skills and attitudes which are supposed to be useful to solve problems in later life. These aspects or purposes of formulating objectives are elabora-ted further.

3.1 The instructional objectives direct pupil growth:

Pupil growth means a balanced development of intellectual, emotional, physical, social and vocational aspects of the human personality. The instructional objectives state them explicitly as pupil behaviours related to desired abilities, skills and attitutes for communication to the curriculum users, i.e. teachers, pupils and examiners. On the other hand, syllabuses and text-books provide only a list of content units and within units content elements with varying degree of depth. Until and unless, the text-books are handled purposefully to direct development of desired qualities, they do not promote pupil growth. They rema-in confined to serve the purpose of content banks, which if not up-dated in latter life, may become obsolete, and also liable to be forgotten. While the abilities and skills acquired and the attitudes formed developing one's conscience in accordance with instructional objectives are easily reta-ined and used to solve life-probl-ms as well as be[illegible] socially useful citizens. With this point of view, the use of text-books is recommended as "d-ta source" in realising the instructional objectives in order to ensure pupil growth in desired direction.

3.2 The instructional objectives guide and control the entire teaching-learning programme:

Instructional objectives provide clear guidelines to teachers and examiners on 'what is expected of pupils after having gone through a particular course of study.' This

helps teachers in choosing the best teaching-learning processes, i.e. the content, methods, materials, pupil motivations, evaluation and feed-back in order to offer most appropriate 'teaching, learning experiences' (figure 1). Testing becomes part and parcel of the teaching-learning programme with provision of feed-back to improve it. This makes teaching and testing objective based and purposeful. Text-books, teachers' guide and students' guides for the text-books help in realising the stated objectives.

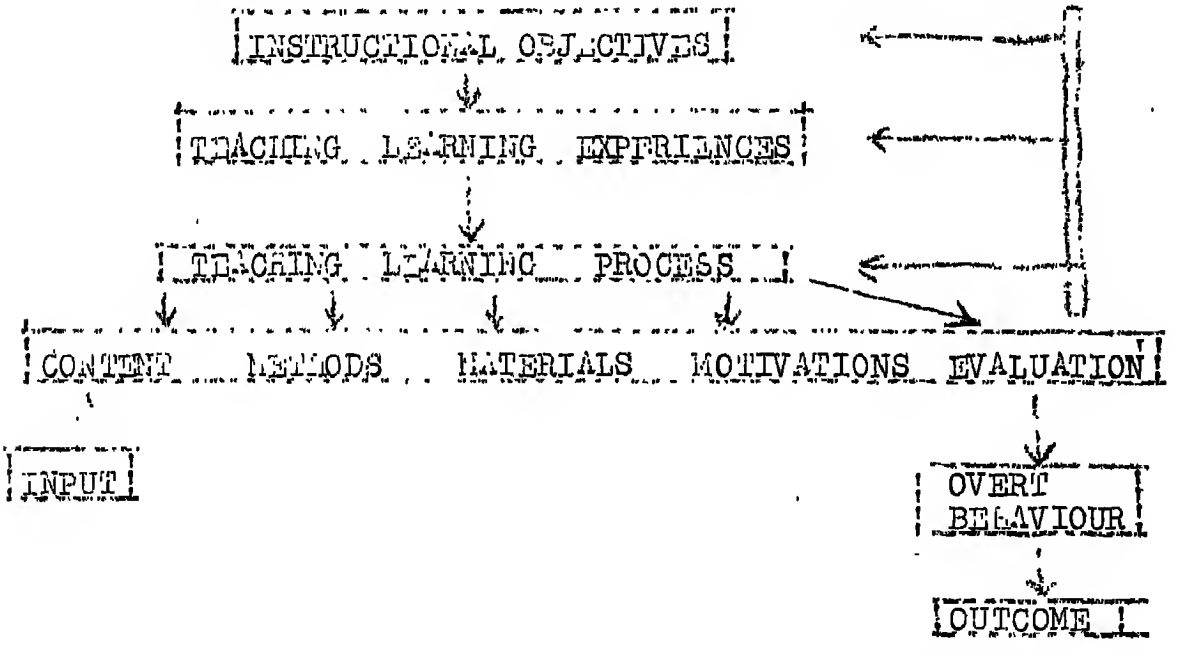

Figure 1: Role of Instructional Objectives in teaching and testing.

3.3 Instructional objectives promote better learning:

Pupil evaluation involves an element of analysis and interpretation of pupil performance in periodical tests and terminal examinations including, sometimes, the public examinations too. This analysis may reveal weaknesses of pupils in certain areas as well as inappropriateness of the

teaching programme. A careful teacher may take care of his/her weaknesses in improving instruction as well as arrange remedial measures to overcome pupil weaknesses. This helps in promoting pupils' better achievements and improving efficiency and effectiveness of teaching.

3.4 Instructional Objectives develop active student involvement in learning.

When a student knows what is expected to learn, he takes initiative for his own study outside of class-room. Statement of expected behaviours when made known to pupils, motivates them to acquire and develop stated abilities and skills. Learning becomes meaningful and purposeful for them. They participate in the learning process actively instead of remaining passive receivers; they can select appropriate materials from the text-book and other sources and even initiate discussion in the class-room.

4.0 DERIVATION OF INSTRUCTIONAL OBJECTIVES:

Systematic work to derive educational objectives is still in an inchoate stage. So far, the subject matter or knowledge has almost been the sole consideration for determining objectives of education. This has widened the gap between the school and post-school life of individuals as well as between school and society. The individuals have also been affected adversely as their emotional, physical, vocational and social needs are neglected. In fact, in order to shape young children into self-reliant and socially useful citizens of tomorrow, knowledge organised under

fferent subject fields should be used only as means to sure a steady growth of pupils rather than as an end in self. Wind of such a change is now blowing which is, though ow but, no doubt, steady. Several nuffield O-level projects ve given priority to education over subject area. N.C.E.R.T. s has started pioneering work in this direction. This· olves a due consideration of the sources determining ructional objectives.

M.C. Neil (1969) emphasized that the subject matter, e learner, and the society, all should be considered as ta source in order to formulate instructional objectives. is, however, omits the resources, both human and physical, ich while effecting the accomplishment of objectives, limit em in their length and breadth. Therefore, it would be eful to base our educational objectives on these four terminants, i.e. society, learner, nature of the discipline d the resources.

1 Society as determinant of educational objectives:

It is needless to say that society is the most powerful aimant to declare what is expected of to-day's pupils after ving received the education, for the schools and colleges e social institutions created, financed and maintained by e society in order to fulfil her own needs and aspirations. ere may be such needs as preserving and transforming the ltural heritage, instilling democratic values of life, oviding skilled man-power and defending the freedom and ity of the country. Therefore, every society aspires

to educate pupils in order to make them self-reliant and emotionally balanced individuals as well as socially useful and responsible citizens. Various commissions and committees on education in India and abroad have reiterated these needs and aspirations time to time.

As early as 1918, the Secondary Education Commission in America stated the seven cardinal principles of education, i.e. health, command of fundamental processes, worthy home membership, vocation, citizenship, worthy use of leisure, and ethicised character. The Indian Education Commission (1966) popularly known as Kothari Commission has clearly stated the need of democratic India for fulfilment through education, e.g. preparing for the democratic way of life, inculcating spirit of secularism, providing work experience to pupils, equipping to live in rapidly advancing world of science and technology, etc. Recommendations of the Education Commissions, National Policy on Education, 1986 and other policy statements of the Government on education, and research studies of eminent scholars in the field lead to develop educational objectives at the national level reflecting the social needs cultural heritage and constitutional obligations for fulfilment in order to maintain India as sovereign socialist secular democratic Republic following the path of justice, liberty, equality and fraternity.

4.2 Learner as the determinant of education objectives:

The learner contributes for the determination of educational objectives indirectly. Success of a teaching programme depends largely on the learners who are at the receiving end of the educational process. Their needs and aspirations force to formulate additional objectives. For example, every individual needs a physical, emotional and social security as well as aspires success in life, earning his/her livelihood honourably and securing social prestige and goodwill. For fulfilling these needs and aspirations of pupils they are to be equipped with certain abilities, skills and attitudes which are to be incorporated explicitly in the educational objectives. In no case, these objectives are in contradiction with the needs and aspirations of the society. In fact society, too, aspires that their future citizens should be self-dependant, open-minded and socially useful individuals.

Interests, asptitudes and abilitie of the learners do exert some influence on the educational objectives but these, more exactly, direct curriculum organisation and teaching techniques. Pupils' maturation level and educational standards also limit the scope of educational objectives. Educational and social psychologists help educationists in this regard while determining and formulating educational objectives, properly graded for various levels of education.

4.3 Discipline as determinant for educational objectives.

The disciplines have always exerted an overwhelming influence on the determination and formulation of educational

objectives. The emphasis on acquisition of knowledge has been so much that it has become the sole objective of education. It has not only hampered in developing pupils' balanced personality but also choked the growth of the discipline itself. In fact, the nature and philosophy of a subject need to be considered alongwith other determinants while deriving objectives for a particular discipline rather than to depend only on the knowledge aspects of that subject. The nature and philosophy of science, for example, has been depicted by three interpenetrating components, i.e. Body of knowledge, Methods of making inquiry, and An Influence on the Environment and Man (School Council , 1974). This reflects clearly that teaching of science cannot be confined merely to body of knowledge but rather will have to base on both processes and products of science on one hand and its impact on the society at large on the other hand. Science is a social force or influence and an essential part of culture and, so derivation of educational objectives based on the nature and philosophy of science will bring no conflict between science and society. Therefore, there is a need to base derivation of objectives after having considered the nature and philosophy underlying a discipline rather than its knowledge component alone. A model for depicting the nature and philosophy of a discipline is outlined in figure 2.

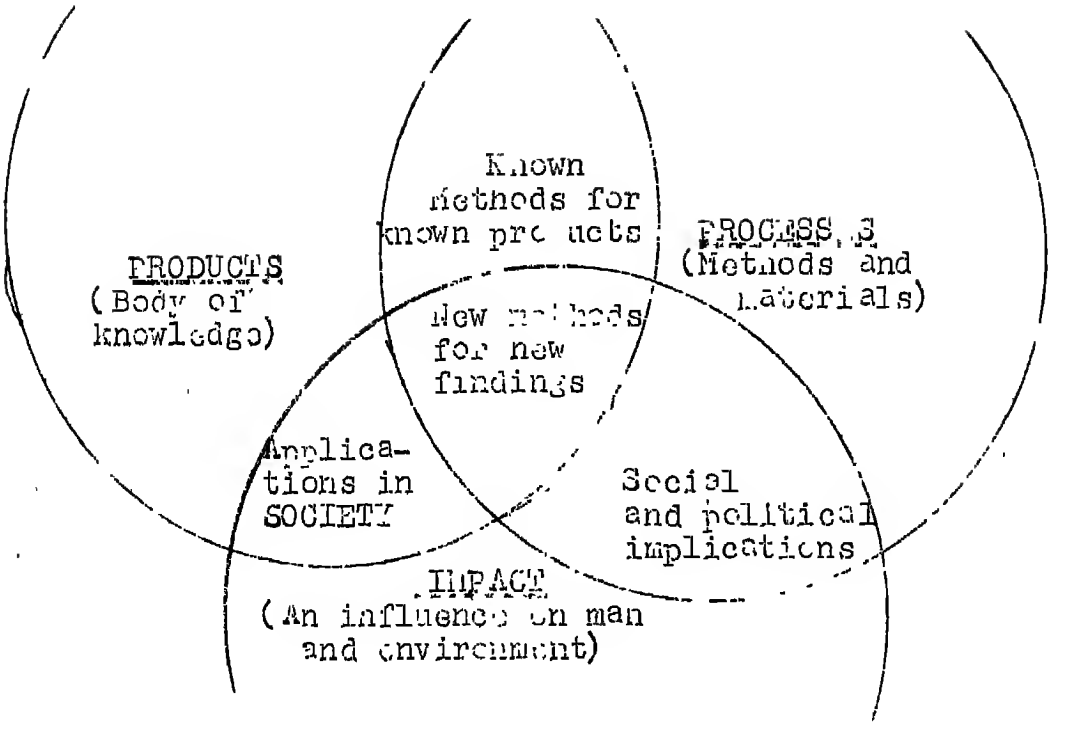

Fig.2 A model for depicting nature and philosophy of a discipline.

4.4 Resources as determinant for educational objectives

Resources are not considered to be the direct sources of educational objectives but realization of objectives depends largely on them. Therefore, it is very much needed to visualise before hand the human and physical facilities, school environment and funds for making provision for additional equipment, refe[illegible] a board, audo-visual aids including radio and television, and inservice training of teachers. While doing so, the attainability of the educational objectives is enhanced, and at the same time some instructional objectives are likely to be added, e.g. in science subjects, improvisation of apparatuses, collection of materials and their preservation etc.

5.0 SUMMARY AND CONCLUSIONS:

Instructional Objectives are the policy statements made by the curriculum planners, educationists and teachers at different levels to express and desire behavioural changes in the pupils after having gone through a particular course of study. These statements for a particular level and for all or one specific subject(s) are derived after having considered the four basic determinants, i.e. the society, the learner, the discipline and the resources. The subject teachers are party to developing of these statements in one way or the other. They will have to elaborate them further while stating expected pupil behaviours for a particular course of study for the whole year (course-level) or the teaching-topic (lesson-level). While doing so, it is expected of them that they would not like to confine the instructional objectives to the cognitive aspects of learning but will educate pupils through the year's course, units of study, or lessons under a particular subject in developing desired intellectual abilities, skills and attitudes as laid down in advance at the National, State, School, or other levels of educational planning.

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CLASSIFICATION AND FORMULATION OF INSTRUCTIONAL OBJECTIVES *

1.0 INTRODUCTION:

Instructional objectives make the back-bone of the entire system of education. In fact, education is concerned with bringing about the desired changes in the behaviour of a learner to ensure a steady growth in right direction. This task is initiated, guided and controlled by the objectives as they express -- the desired changes in a pupil's behaviour and determine the extent and direction of pupil growth. This demands a proper formulation of instructional objectives, without which, the instructional programme is liable to become dull, non-directional and haphazard.

A society can no longer survive and flourish without having a continuous supply of properly educated and tra-ined individuals in sufficient number to perform various tasks concerned with preservation and perpetuation of her cultural heritage, values and ideals as well as to fulfil social needs. This is why the instructional objectives are derived as desired behavioural changes according to the social needs and values, nature and scope of the individual subjects of study, maturation level and needs of the learners and the resources can be geared at various levels of education.

Objectives, so developed, lead to the entire system of instruction including pupil evaluation. They initiate the teaching learning process, guide and control for its smooth conduct through the selection of most appropriate content and best methods and end it by governing the process of

* J.P.AGARWAL, READER, DMES&DP,NCERT, NEW DELHI-110016.

pupil assessment. Thus the instructional objectives occpy a key position in the entire system of education. They can make or mar the success of teaching and direct educational process to produce either individual who can add feathers to one's cap or prepare rotten apples injuring the companions. Therefore, it is utmost essential to formulate instructional objectives stated appropriately to ensure desired growth and classified properly to arrange them in a graded order directing steady growth step by step.

2.0 NEED OF A CLASSIFICATION MODEL:

The instructional objectives when formulated specifically for accomplishment in a particular subject, produce a very long list of statements. This list, without having an appropriate system of classification may involve repetition, overlapping, contradiction, scattering, unwieldiness and discontinuity. Classification scheme can be developed as practised in biological sciences where organisms on certain approved criteria are arranged into certain phyla, classes, orders, families and genera.

A classification of instructional objectives is useful in categorising objectives into categories and sub-categories on one hand, and overcoming the problems, stated above, on the other. By identifying the major categories of objectives and stating objectives at desired level of generality, the problem of unwieldiness can be looked into. This also helps in locating repetition, contradiction and overlapping of objectives. On the other hand, it would also reveal what

other objectives have been left out. If the classification arranges the objectives in order to complexity, the problem of discontinuity will no longer remain. Thus a suitable system of classification for instructional objectives is a must, and educationists and measurement experts have worked hand in hand to evolve suitable classification models. This would also assist in ascertaining the comparability of standards and effectiveness and efficiency of the teaching programmes.

3.0 BASIC CRITERIA OF THE CLASSIFICATION MODELS:

For developing a workable system of classification appropriate criteria are to be determined for categorising objectives. Teachers are usually bewildered by too many systems of classifying objectives, i.e., general and specific objectives, tangible and intangible objectives, short-range (proximate) and long-range (ultimate) Objectives etc. In fact, it needs a logical scheme for grouping objectives of instruction which may be meaningful, handy and useful.

Each statement of an educational objective usually has two distinct component, a modification part directing the pupil behaviour, and the other content part relating the behaviour with subject matter. A few workers tried to develop classification models with the latter component. The subject oriented classifications, so developed, were much complex with unending list of objectives or too general to direct the teaching learning programme. Process oriented

classifications were evolved on the basis of modification part which were found workable. In fact, education is concerned to bring about a change in the behaviour of the learner, and so classification of objectives should be based on the behavioural part of the objectives. The content part may be tagged to the classified behaviours. Such a system would give a various categories of behavioural objectives quite common in most of the subjects. This would help in comparing pupil achievements in their two or more subjects of study.

There was one more problem still left unsolved with the taxonomists and that was how to arrange behaviours into various categories and sub-categories. Bloom and his associates developed an hierarchical system for arranging various categories of behaviours (or objectives) in an ascending order of complexity, based on mental operations involved. For example, recall of characteristics of the family Cruciferae is simpler than to enumerate differences between Cruciferae and Malvaceae.

4.0 BLOOM'S MODEL OF CLASSIFICATION OF OBJECTIVES.

Bloom and his associates has adopted a tripartite division of the entire realm of mental life, i.e. cognitive, Affective and Psychomotor domains concerning to knowing, feeling and doing aspects of behaviours. These represent learning by head, heart and hand respectively. The basic features of these classifications include identification of major categories of behavioural objectives and arranging them in an hierarchical order of complexity in mental

operations, sub-divide the categories into sub-categories using a decimal system, tagged content elements with the categories and sub-categories, and cumulative nature of the categories to maintain continuity from simple to complex.

4.1 COGNITIVE DOMAIN:

This classification scheme was available in 1956 and is found most workable with almost all subjects of study and for all levels of education. The various categories and their subdivisions are mentioned here (B.S.Bloom et at,1956)

1.00 Knowledge.

1.10 Knowledge of Specifics:

1.11 Knowledge of terminology.

1.12 Knowledge of specific facts.

1.20 Knowledge of ways and means of dealing with Specifics:

1.21 Knowledge of conventions

1.22 Knowledge of trends and sequences.

1.23 Knowledge of Classifications and categories.

1.24 Knowledge of Criteria

1.25 Knowledge of Methodology.

1.30 Knowledge of the Universals and Abstractions in a field:

1.31 Knowledge of Principles and Generalizations.

1.32 Knowledge of Theories and Structures.

3.00 COMPREHENSION

2.10 Translation

2.20 Interpretation.

2.30 Extrapolation.

3.00 APPLICATION:

3.10 Applies to solve unfamiliar problems.

4.00 ANALYSIS:

4.10 Analysis of Elements.

4.20 Analysis of Relationships.

4.30 Analysis of Organizational Principles.

5.00 SYNTHESIS:

5.10. Production of a unique communication.

5.20 Production of a plan or proposed set of operations.

5.30 Derivation of set of Abstract Relations.

6.00 EVALUATION:

6.10 Judgements in terms of internal evidence.

6.20 Judgement in terms of external criteria.

The six categories of behaviours in this scheme are arranged simple to complex. Each category, in addition to its own, includes the mental operation involved in the former ca-tegory or categories, thus possessing cumulativeness and maintaining continuity. This means the category of Application is equal to 'understanding plus application' or 'knowledge plus understanding plus application.'

4.20 AFFECTIVE DOMAIN:

This domain deals objectives concerned with 'feeling'

aspects of learning. Dr. Krathwohl et al (1964) developed this scheme under the leadership of B.S. Bloom after a pains taking team work. This taxonomy is developed on the parallel lines to the earlier one, arranging objectives involving initial and simplest behaviours through value-guided behaviours to behaviours expressed in accordance to one's conscience. The major categories and their sub-divisions are mentioned here:

1.00 RECEIVING (= ATTENDING)

- 1.10 Awareness
- 1.20 Willingness to receive
- 1.30 Controlled (or Selected) Attention

2.00 RESPONDING:

- 2.10 Acquiescence in responding
- 2.30 Satisfaction in response.

3.00 VALUING:

- 3.10 Acceptance of a value
- 3.20 Preference for a value
- 3.30 Commitment (Conviction)

4.00 ORGANIZATION:

- 4.10 Conceptualization of a value.
- 4.20 Organization of a value system.

5. CHARACTERIZATION BY A VALUE OR VALUE COMPLEX:

- 5.10 Generalized set.
- 5.20 Characterization.

The taxonomy of the Affective domain is much less popular possibly due to comparatively less emphasis on affective

objectives for accomplishment in the schools and partly because teachers still feel to use categories like appreciations, interests, attitudes, values and habits. In fact, these traditionally classified affective objectives involve overlapping values, from 'awareness of a fact' to the 'conceptualisation of a value'. However much work needs to be done in this area. 'Rajasthan scheme of comprehensive Internal Assessment' was emerged as a result of cooperative efforts of several educational workers and deals some of the affective objectives much better under the 'personal and social qualities' 'interests' and 'attitudes'.

4.30 PSYCHOMOTOR DOMAIN:

This domain includes behavioural objectives pertaining to skills (doing aspects of human learning).

4.31 SIMPSON'S MODEL:

Elizabeth Simpson (1966) and her associates has outlined a system of classification for the psychomotor domain on the similar lines as are the two classifications for the cognitive and affective domains. The major categories and sub-categories are mentioned here:

1.00 PERCEPTION:
- 1.10 Sensory stimulation
- 1.20 Cue selection.
- 1.30 Translation

2.00 SET
- 2.10 Mental set

2.20 Physical set

2.30 Emotional set.

3.00 GUIDED RESPONSE

3.10 Imitation

3.20 Trial and error.

4.00 MECHANISM

4.10 Patterning of responses.

5.00 COMPLEX OVERT RESPONSE

5.10 Resolution of uncertainty

5.20 Automatic performance.

6.00 ADAPTING AND ORGANIZATION:

(Developing New Patterns of action)

6.10 Improvisation

6.20 Modification

This taxonomy has not yet been worked out fully and still needs further development.

4.32 R.H. DAVE'S MODEL

R.H. Dave (1968) in his paper presented at the International Seminar on 'testing' organised at Berlin outlined a classification model for the Psychomotor Domain which has well thought out and tried out in detail. The major categories and sub-categories are mentioned here.

1.00 IMITATION:

1.10 Imprision

1.20 Overt repetition.

2.00 MANIPULATION:

2.10 Following direction.

2.20 Selection

2.30 Fixation

3.00 PRECISION:

3.10 Reproduction

3.20 Control

4.00 ARTICULATION:

4.10 Sequence

4.20 Harmony

5.00 NATURALISATION

5.10 Automatism

5.20 Routinization.

This model presents from the acquision of simple and complex skills to their mastery and bringing them in habit as reflex actions.

4.33 HANNA AND MICHAELIS MODEL:

L.S.Hanna and J.C. Michaelis (1977) has further elaborated the hierarchical classification of the affective domain which has been advanced by Prof. R.H. Dave (1968).

1.00 IMITATING:

Performs the steps demonstrated by the teacher. Abilities: Observing, remembering, copying and reproducing.

2.00 PATTERNING:

Practices step under teacher's instruction (without actual demonstration) as well as independently by trial and error. Abilities: Comprehension of instructions, remembering of instructions, translation, trial and error efforts, blending of steps, independent execution.

5.00 MASTERING:

Independent execution of skills in a specific situation with precision and speed (out-line instructions may be needed). Abilities: appropriate precision, speed, agility, coordination, adherence, proportion and strength.

4.00 APPLYING:

Independent execution of skill in a desired schedule in a variety of situations with precision, speed and efficiency; recommends new situations for employing this skill. Abilities: identification of appropriate skills to solve problems, performing the task precision, speed.

5.00 IMPROVING:

Independent and intentional execution of skill with bringing in it some modification or introducing new elements; uses the skill creatively and flexibly in a variety of situations; creates new patterns or sets up new experiments. Abilities: identifying a situation where a particular skill can be applied appropriately, modifying the steps of the skill, adapting or introducing new elements to the skill.

4.34 IMPLICATIONS OF TAXONOMY OF PSYCHOMOTOR DOMAIN:

These taxonomies have influenced the identification of simple and complex skills and their grouping in major categories and sub-divisions with behaviours expressing their graded acquisition, mastery and independent execution with needed manipulative modification. The various categories

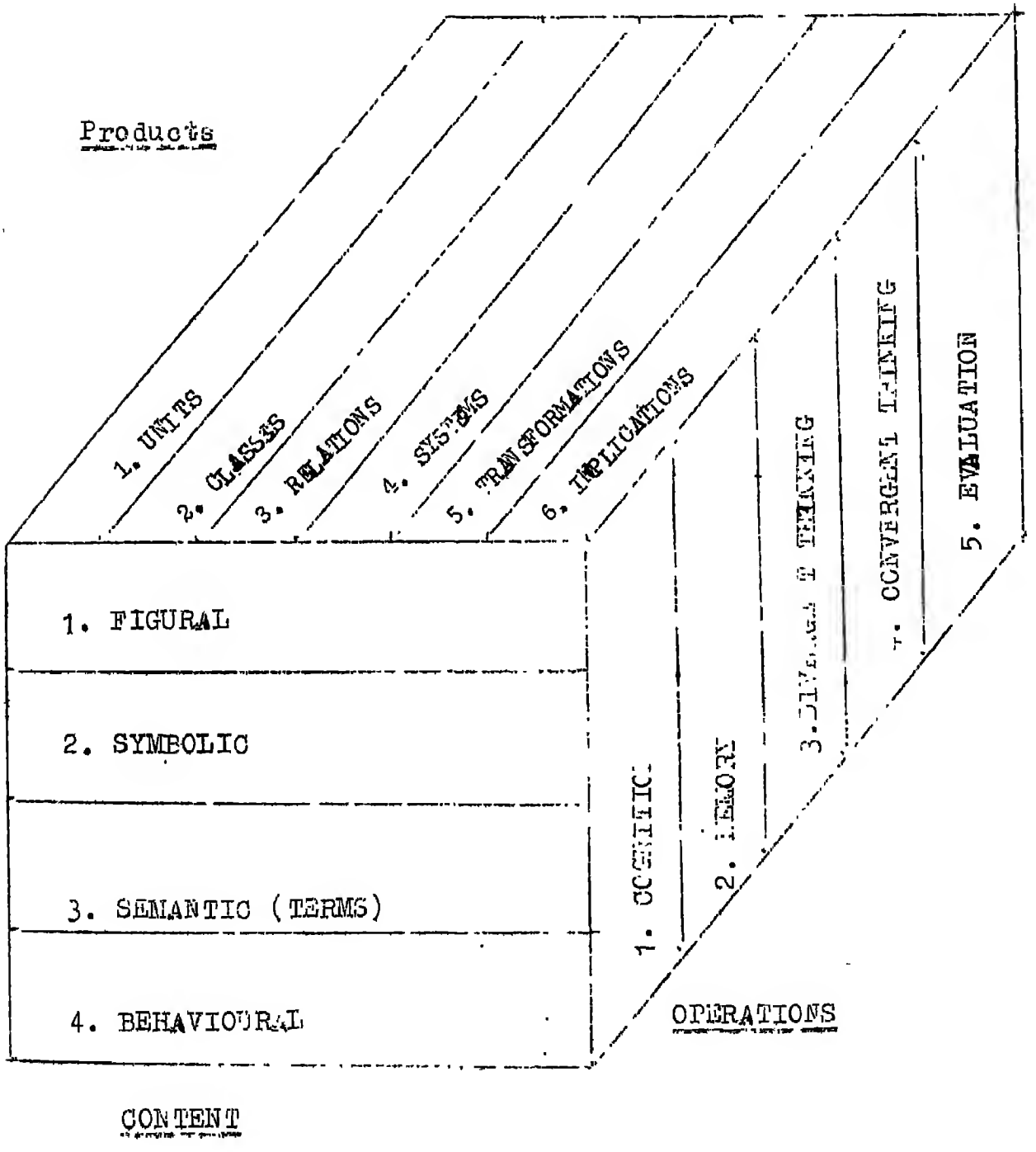
of skills in biological sciences include Observational Skills (recognises relevant details, reads quantitative data) locates desired data, discriminates between related data and detetes error), Drawing Skills (draws, labels, shows directions), Manipulative skills (selects, handles, measures, sets the experiment, takes precautions, detects error and rectifies them, improvises, calculates), Collecting Skills (locates, collects, preserves, mounts, displays and Reporting Skills (records data, selects content and style, presents evaluatively). This would be useful to prepare instruction objectives for practical work in sciences for teaching and testing purposes.

5.0 GUILFORD'S MODEL ON STRUCTURE OF INTELLECT.

He has visualized three faces of intellect with further divisions of each face to make 120 cells or dimensions, each representing a mental process (figure 1) about 90 mental processes has been recognised so far.

This is a complex model and needs psychological approach in identifying the various mental processes. As such it is difficult to follow for our educational testing programmes.

Figure 1: A three Dimensional Model on Structure of Intellect (Guilford).



6.0 EBEL'S MODEL FOR COGNITIVE DOMAIN:

Robert L. Ebel prefers to classify educational objectives on the basis of "task" performed during testing. According to him it is difficult to identify the mental processes and so Bloom's approach for classifying various categories of objectives into specification on the basis of mental operations is not practicable for the classroom teachers and paper setters. The major task identified by Ebel are mentioned herewith minor modifications.

1.00 Understanding of terminology.

2.00 Understanding of facts and principles.

3.00 Ability to explain phenomena and relationships.

4.00 Ability to calculate solving numerical problems

5.00 Ability to predict in specified situations.

6.00 Ability to recommend appropriate action in some specific problem situations.

7.00 Ability to make an evaluative judgement.

This way of classifying instructional objectives is much easier and practicable. N C E R T Model on Educational Objectives has followed Bloom's approach but specified the task under each category almost similar to Ebel but more comprehensively (Refer 8.00).

7.0 INTERRELATION BETWEEN DIFFERENT DOMAINS

The tripartite division of educational objectives into three domains followed in the Bloom's model is not a water-tight compartmentalization. This is simply to maintain classifications separately for the convenience sake. EISS (1968) has expressed similar views as demonstrated in fig. 2 showing interrelationship among the three domains.

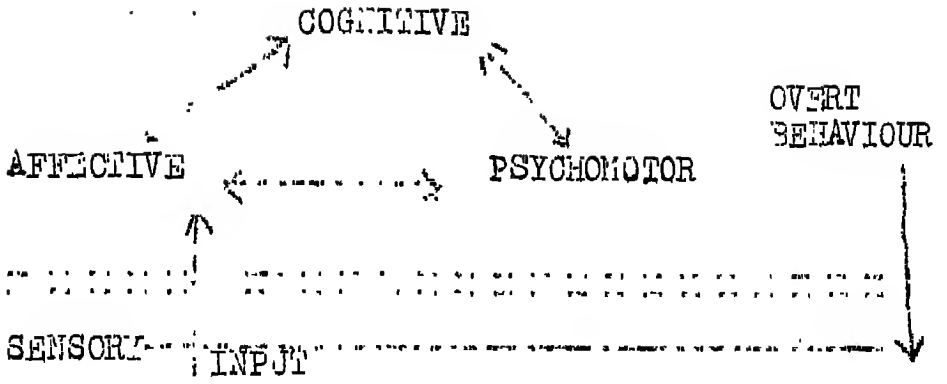


FIGURE 2: Inter-relationship among the three Domains

In this model the base line represents the barrier that plays between the conscious and subconscious mind. When this barrier is successfully penetrated by a stimulus, the individual becomes conscious of it. At this stage, we say that the "awareness of stimulus" has achieved (Affective Domain). Cognitive activity occurs to decide whether or not he is interested in its further exploration. If he decides for further exploration of the stimulus, a "tell me more" type reaction results which means curiosity has been developed. If he continues to give attention to the stimulus the curiosity turns into interest. During this mental activity, psychomotor responses like observing, reading, writing, talking, etc. occur involving all the three aspects of learning - Cognitive, Affective and Psychomotor. An interplay between these three aspects of the consciousness

is thinking. New information is stored in the "individual's memory bank" as learning which is displayed by a psychomotor activity, observable in the form of an 'overt behaviour'.

This model represents the learning process as well as inter-relationship between the three domains. And also that measurement depends on pupils' overt behaviours displayed with the help of psychomotor activity.

8.0 NCERT MODEL OF INSTRUCTIONAL OBJECTIVES:

National Council of Educational Research and Training New Delhi has evolved a model on taxonomy of instructional objectives. In essence, it adopts Bloom's approach but with certain changes. The first two categories of the cognitive domain are kept in tact but remaining all other categories are assembled under one name APPLICATION. This application of NCERT model includes application, analysis, synthesis and judgement of Bloom's model of the Cognitive Domain. Secondly the specifications given by decimal system are further elaborated to specify explicitly the so called mental operations but they appear almost like Ebel's tasks. These make the objectives clear, meaningful and practicable.

A third modification is to keep all the three domains one after the other in a sequence, cognitive-psychomotor-affective. The hierarchy of the behaviours according to increasing complexity is maintained within the cognitive domain and work is going on to develop the same in terms of specific behaviours for various skills on one hand, and for appreciations, interests, attitudes and adjustments on

the other. The entire scheme is mentioned in Table 1. Minor changes in the specifications are allowed to accommodate different subjects and for different levels of education.

TABLE 1: N.C.E.R.T. MODEL ON CLASSIFICATION OF INSTRUCTIONAL OBJECTIVES:

1.0 KNOWLEDGE:

Knows content elements, like terms, definitions, facts, techniques, processes, classifications, concepts, principles and generalizations related with the subject.

SPECIFICATIONS:

1.1 Recalls/recognises terms and definitions.

1.2 Recalls/recognises fact and events.

1.3 Recalls/recognises trends and sequences.

1.4 Recalls/recognises criteria, categories and classification.

1.5 Recalls/recognises procedures.

1.6 Recalls/recognises concepts, principles and functions.

1.7 Recalls/recognises theories and generalisation.

2.0 UNDERSTANDING:

Comprehends the various content elements i.e., terms, facts, techniques, processes, classifications, concepts, principles and generalisations.

SPECIFICATIONS:

2.1 Translates content elements from one form to another.

2.2 Cites examples involving one or more content elements.

2.3 Identifies relationships between two or more content elements.

2.4 Detects error in statements, diagrams, etc.

2.5 Compares one or more content elements to report similarities and differences.

2.6 Classifies various content elements on the basis of given or evolved criteria.

2.7 Interprets various types of data and concepts related to the content.

2.8 Explains the various content elements like processes, techniques, cause - effect relationships, etc.

2.9 Extrapolates for the future on the basis of given facts, data, etc.

3.0 APPLICATION

(Application, Analysis, Synthesis and Evaluation of Bloom's model):

Applies knowledge and understanding of the various content elements in unfamiliar situations.

SPECIFICATIONS:

3.1 Analyses the given data or situations to identify the various components and their relationships.

3.2 Makes hypothesis (or most suitable explanations) on the basis of given or observed data.

3.3 Establishes relationship between cause and effect.

3.4 Gives reason(s) for certain causes and effects.

3.5 Infers or Generalises from the given data or observation

3.6 Predicts from the observed and/or given data,

3.7 Judges the relevance, adequacy, and consistency of the facts, principles and generalizations in the given statements, data, procedures, processes, etc.

3.8 Develops a unique communication/alternative procedure or plan of action for the given purpose.

4.0 SKILLS:

Develops skills in observing, drawing, conducting, experiments; collecting, preserving and displaying exhibits; reporting, etc.

SPECIFICATIONS (According to various types of Skills)

4.1 Observational skills:

4.11 Notices/recognises relevant details in diagrams, specimens, chemical changes, phenomena, processes procedures, apparatuses, instruments, etc. carefully (Keen Observation).

4.12 Reads the instruments, graphs, tables, etc. precisely and methodically (Quantitative Observation).

4.13 Locates the desired information, structures, materials, phenomena etc. exactly. (Precise Observation).

4.14 Discriminates between closely related data, structures, specimens, organisms, etc. (Comperative Observation).

4.15 Detects error in experimental procedures, apparatuses, instruments, etc. (Evaluative observation).

4.2 DRAWING SKILLS:

4.21 Draws diagrams, figures, graphs, maps, tables, charts from the given material/data faithfully, neatly, proportionately, to the desired scale and with reasonable speed.

4.22 Labels diagrams, maps, charts, etc. methodically neatly, legibly and correctly.

4.23 Completes diagrams, graphs, figures etc. correctly which are incompletely drawn.

4.24 Traces figures and electric circuits, etc. accurately.

4.25 Shows directions in flow charts, action diagrams, etc. correctly and methodically.

4.3 MANIPULATIVE SKILLS:

4.31 Selects apparatus, chemicals, materials, etc. appropriately;

4.32 Arranges the apparatus systematically.

4.33 Handles the apparatus, chemicals, etc. carefully.

4.34 Measures (reads) quantities with correct procedure and precision.

4.35 Maintains instruments, apparatuses, chemicals, specimens, etc.

4.36 Improvises apparatus/techniques as per requirement.

4.37 Sets the experiment carefully, systematically with reasonable speed.

4.38 Performs the experiment methodically and with accuracy and reasonable speed.

4.39 Takes necessary precautions and safety measure in handling instruments, chemicals, etc.

4.4 COLLECTING, MOUNTING, PRESERVING AND DISPLAY SKILLS:

4.41 Locates the place of occurrence easily.

4.42 Collects materials, specimens, etc. efficiently, economically, methodically, and timely.

4.43 Uses the apparatuses, instruments, chemicals, etc. for collection, mounting, preservation and display economically and efficiently.

4.44 Mounts the specimens, etc. appropriately and effectively.

4.45 Selects appropriate chemicals, instruments for collecting, mounting, preservation and displays.

4.46 Displays his collections, charts, maps, graphs, exhibits, etc. effectively.

4.5 REPORTING SKILLS:

4.51 Records observations, data etc. faithfully, systematically and according to the design of the experiment.

4.52 Selects appropriate terminology, graphs, figures, maps, tables, formulae, chemical equations, symbols and principles for writing the report of the experiment.

4.53 Presents principles involved, methods and materials, observations, data, calculations, analysis and interpretations, conclusions, limitations, and precautions systematically, coherently, succinctly and evaluatively.

4.54 Uses simple, clear, precise and unambiguous language in the report.

4.55 Develops a summary of the report including findings and suggestions.

4.56 Displays his results, exhibits, etc. effectively and appropriately.

5.0 APPRECIATIONS:

Appreciates natural phenomenon and laws, contributions of subject experts and their achievements, role of the subject in human life, etc.

SPECIFICATIONS:

5.1 Develops an awareness of science and its contribution to human welfare.

5.2 Recognises interdependence in life, unity of life in diversity of forms, etc.

5.3 Obeys the instructions, rules etc. in his work.

5.4 Realises the worth of scientists and their contributions etc.

5.5 Admires the beauty of nature and its organizational laws, etc.

6.0 INTERESTS:

Develops interest in the living world.

6.1 Is conscious of the scientific development and its impact on human life.

6.2 Listens the scientific talk with interest.

6.3 Reads scientific magazines voluntarily to seek new information.

6.4 Collects materials of scientific interest.

6.5 Visits places of scientific interest.

6.6 Enjoys participation in scientific activities, hobbies related to science, etc.

6.7 Initiates discussion on topics of scientific interest.

6.8 Writes scientific articles for the press.

7.0 ATTITUDES AND ADJUSTMENTS:

(1) The pupil develops the scientific attitude towards the nature, natural phenomenon and personal and social life.

(2) The pupil develops adjustment to modify the environment or to himself.

SPECIFICATIONS:

7.1 Practices the rules and regulations of scientific work voluntarily (Compliance of instructions.)

7.2 Believes in cause - effect relationship.

7.3 Observes intellectual honesty in his work and in life.

7.4 Suspends judgement in the absence of adequate and appropriate evidence.

7.5 Devotes time to convince others for following scientific reason in solving problems, for conservation of natural resources and maintenance of balance in nature, etc.

7.6 CHANGES his opinions when convinced by others (open-mindedness).

8.0 FORMULATION OF INSTRUCTIONAL OBJECTIVES:

After having an idea of the nature and characteristics of instructional objectives, their place in the educational system, sources for deriving them, and classification models developed for categorising them, one should begin with the selection of desired objectives, state them at proper level of generality tagging with appropriate content elements, and organise them following the NCERT model mentioned in column 8.0 for this purpose.

9.1 Basic principles for selecting objectives.

The following criteria or principles may be observed while selecting objectives of teaching and testing a specific course at particular level of education in order to avoid an unwieldy list of instructional objectives.

9.11 Worthwhileness and significance:

An Objective should be worthwhile; it should state a significant behaviour with reference to an academically and/or socially desirable aspect of learning.

9.12 Attainability and practicability:

It should be attainable well within the means of the

teacher i.e., teaching facilities, pupils, maturation level and teacher's competence.

9.13 Measurability and predictability:

The instructional objective, as far as possible, may be assessed using the tools and techniques of evaluation with reasonable accuracy; in other words valid and reliable assessments may be made to ascertain the effectiveness of teaching as well as the desired change in the behaviour of pupils. In fact, it should predict a pupil's behaviour appropriately.

9.14 Challenging Nature and Principle of Flexibility:

The objective should be challenging enough to a pupil, motivating him or her to learn. As there are individual differences within a class, it would be advisable to maintain flexibility to accommodate all.

9.15. Comprehensiveness and conformity to national priorities:

The objectives when considered together should cover all areas of learning--intellectual, emotional, physical and social. It is another thing that some of the objectives may need special tools and techniques for measurement. Each subject should cover the optimal range of objectives covering all aspects of pupil growth. Thus, objectives of each subject may lead to fulfil national priorities and in this way pave the way for accomplishment of National Goals of Education.

9.16 Level of Generality.

The objective should be framed at the desired level of generality so that it directs pupil growth explicitly. It should be neither be too general nor atomistic. It must spell out the purpose for which intended.

9.17 Non-composite nature of objectives.

An objective should include only one type of objective with one or more but related areas of content. Two objectives should not be combined together to avoid overlapping and confusion.

9.18 Repetition overlapping and contradiction:

The list of objectives so developed should be free from repetition, overlapping and contradiction. This would also shorten the list and make it handy avoiding to become unwieldy list of objectives.

9.19. Principles of continuity and togetherness.

The objectives should be organised in a suitable system of classification in order to place them in an hierarchical order to ensure a steady and continuous growth of pupils in various aspects of human learning. This would also bring similar objectives together avoiding scattering of them.

9.2 GUIDELINES FOR STATING INSTRUCTIONAL OBJECTIVES:

Educational objectives are the intentions to be accomplished as a result of educational programme. These intentions should be expressed in such a way that may carry the direction effectively. Following are the suggestions

which may be observed while stating and formulating objectives. These are in continuation of the basic principles of selecting objectives and so these principles are inclusive.

9.21 The objectives are statements and so should be written in complete sentences involving both behaviour component as well as the content elements. Content elements may be identified as terms, definitions, facts, events, trends, sequences, processes, procedures, criteria, categories, classifications, concepts, principles, generalisations, etc.

9.22 The objectives are stated at various levels of education and so level of generality may be maintained accordingly. Our primary concern is to state them at the subject level and then to unit and topic levels for developing instructional programme as well as questions for the examination papers, unit tests and periodical tests. At all these three levels the behavioural as well as content component will gradually expand in terms of specificity. For example, at the subject level, an objective on understanding may state, "The pupil understands the various content elements related with morphology and functions of root, stem, leaf, flower, fruit and seed including types of inflorescences, modifications of various parts and their specification functions".

The above objective may also be stated as "Understands the concepts, plant structures and functions are complementary to each other". But at the unit level, the above

statement is to be elaborated further. For example, while stating an objective for the unit "Flower structure and Function", it may state as "The pupil understands the concept, flower structure is adapted to its functions". But this is not enough, it must be followed by a few desired specifications, i.e., the pupil compares on certain criteria, etc.

At the topic level, the specifications would be more specific. For example, the pupil compares the structure of stamens belonging to different plants to state similarities and differences, the pupil classifies flowers on the basis of free and fused calyx, free and fused petals and free and fused carpels, etc. Therefore, one can find an increasing amount of details, or in other words, specificity when we move from subject level to unit level and from the latter to the topic level. On the higher levels, e.g. state level or national level, the specificity decreases to make the list more comprehensive but generalised so that single list may be prepared to state objectives for all subjects incorporated together for all classes belonging to one stage of education, e.g. Primary level are put together.

Sometimes, even all stages of the school education are linked together for stating educational goals at the national level. Naturally at this stage, the generality in stating the objective would be maximum. Such statement of objectives may be seen in the reports of various Education Commissions including the 5-year Plans (Refer

the reference, Government of India, 1970: Education in the First 5-Year Plan for National level objectives).

9.23 The objectives should reflect a pupil's terminal behaviour instead of the teacher's intentions or behaviour. It should neither state the teaching-learning process nor the teacher's performance but state clearly the pupil's performance and the outcome of the teaching-learning processes. All these three aspects are interlinked and are further explained by the following illustration.

a) The pupil classifies flowers belonging to different plant species on the basis of stated criteria (states terminal behaviour, outcome of learning and pupil's performance).

b) To enable pupil to classify flowers (states teacher's intentions or behaviour)

c) The pupil observes flower for classification belonging (states process of learning).

) The teacher explains the pupils how to classify flowers (states teacher's performance).

9.24 The instructional objectives should be written in a non-composite manner, i.e. two behaviours should not be combined together. "The pupil compares and classifies flowers.....". is poorly stated objective. In fact, ability to classify is an higher ability than the ability to compare and so it includes the lower ability in itself. Therefore, it would suffice to state, the pupil classifies flowers..... .This objective expects that pupil will identify compare and classify.

9.25 Each objective is written at two levels. First at the category level of the objective, i.e. "the pupil understands the flower parts". Second at the specification level of the objective; in other words, a category of an objective is followed by one or more specifications, i.e. the pupil identifies relationship between flower parts and their functions, "the pupil classifies flowers belonging to different plant species on the basis of stated criteria", etc.

This involves three points:

1) Each objective is stated at two levels, one at the level of the Objective, and this is expressed by more generalised behaviour (Refer Table 1) i.e., knows, understands, applies, draws, appreciates, develops interest in, etc. While the other is at the specification level or at the level of specific learning outcome which is expressed by more specific behaviours. For example, under/understanding objective, by "translates, identifies relationships, explains, classifies, etc."

2) The second level statements are to be arranged with the level of complexity under its respective category. The two specifications i.e. "the pupil identifies relationships between....."and "the pupil classifies flowers ....." are to be placed one after the other under the category"understanding" having more generalised statement i.e. 'the pupil understands.....'. This system arranges objectives in an hierarchical order following the system of

classification (Refer Table 1).

3) The objectives and specifications (or specific learning outcomes) appear two different things. In fact, specifications are the objectives stated in specific behaviours which are attainable and measurable to the extent desired. Examples, of these specific behaviours are: translates, compares, classifies, explains, etc. under the category UNDERSTANDING. On the other hand the term objective is used for the category of objective, it is spelled out less specifically and can not be measured without its specifications. This is just like the binomial nomenclature used in biology. An organism bears two names the former generic and the latter specific, e.g., Homo sapiens. Similarly here each objective is stated with two statements one representing the category of the objective knowledge, understanding, application, etc. and the other its specific objective or behavioural outcome. The latter makes the real objective.

9.26 The specifications or behavioural outcomes may start with an action verb that indicates observable behaviour; that is the behaviour that can be observed by an outside observer.

Objectives stated following these criteria are bound to be free from repetition, overlapping, contradiction, scattering and discontinuity, and at the same time, carry the intent clearly, unambiguously and specifically.

III

ILLUSTRATIVE QUESTIONS SAMPLING THE PROCESS OF PHOTOSYNTHESIS

Objective based questions are given here to make explicit the various specifications listed under three categories of instructional objectives of the cognitive domain. The content area selected for this purpose is the process of photosynthesis, specially, the concept of "Calvin cycle".

1.0 KNOWLEDGE

Knows terms, definitions, facts, events, trends, sequences, criteria, categories, classifications, procedures, concepts, principles, theories, themes and generalisations.

1.1 Recalls or recognises terms and definitions:

Q.1. Name the term used for the process to produce Ribulose 1,5-biphosphate through a series of reactions utilising phosphoglyceraldehyde and ATP during Calvin cycle. 1

Q.2 Which of the following terms is used for the reduction of PGA to PGAL?

A. Carboxylation

* B. Glycolytic reversal

C. Calvin cycle

D. Glycolysis 1

1.2 Recalls/recognises facts and events.

Q.1. Name the scientist who worked out the details of Dark Reaction. 1

Q.4. Which of the following statements states the fact about the glycolytic reversal during Calvin cycle?

A. PGAL utilizing the energy of ATP and reducing power of NADP gets converted to PGAL.

*B. PGA utilizing the energy of ATP and reducing power of NADPH gets converted to PGAL.

C. PGAL utilizing the energy of ATP and oxidising power of NADP gets converted to PGAL. 1

D. PGA utilizing the energy of ATP and oxidising power of NADPH gets converted to PGAL.

Q.5. Energy is transferred from the light reaction step to the dark reaction step by

A. AMP,

B. ADP.

* C. ATP. 1

D. RUBP.

1.3 Recalls/recognises trends and sequences:

Q.6 State three phases of Calvin cycle in a correct sequence. 1

1.4 Recalls/recognises criteria, categories and classifications:

Q.7 Which one of the following sets of substances is produced as a result of Calvin cycle? 1

*A. ADP, glucose and NADP

C. ATP, PG.. and NADP

D. RuBP, glucose and ATP 1

Q.8. State any two substances which participate in the glycolytic reversal of Calvin cycle. 1

1.5 Recalls/recognises procedures:

Q.9 State the procedure of autoradiography as used by Calvin. 2

1.6 Recalls/recognises concepts and principles:

Q.10 Which of the following statements represents the principle involved in the technique of paper chromatography?

A. A spot is formed on the X-ray film by placing a paper chromatogram of a substance having radioactive element.

B. Aquous solution of a chemical shows a distinct colour on a paper.

C. Alcoholic solution of a chemical shows a distinct colour on a paper.

*D. Different chemicals show differential rate of movement on a paper alongwith its solvent. 1

1.7 Recalls/recognises theories and generalisations (or patterns):

Q.11. Which one of the following statements is almost universally acceptable generalisation regarding photosynthesis?

A. All green plants consume light energy, water and CO_2 to produce RuBP and glucose during photosynthesis.

B. All green plants consume ATP, RuBP and CO_2 to produce glucose and O_2 during photosynthesis.

*C. All green plants consume light energy, water and CO_2 to produce glucose and O_2 during photosynthesis.

D. All green plants consume light energy, NADP, water and CO_2 to produce RuBP, glucose and O_2 during photosynthesis. 1

2.0 UNDERSTANDING

Understands terms, definitions, facts, concepts, principles, etc.

2.1 Translates (i.e. includes calculates):

Q.12. State the meaning of $^{14}CO_2$. 1

Q.13. Presents the various steps of C fixation cycle by a graphical representation. No description is required. 4

Q.14. Depict the two reactions involved in the glycolytic reversal by a flow chart. 2

2.2 Gives examples:

Q.15 Which of the following sets of substances belongs to glycolytic reversal?

A. RuBP, ATP and NADP

B. PGA, ATP and Rubisco

C. Rubisco, PGAL and ADP

* D. PGA, NADPH and ATP. 1

2.3 Identifies relationship:

Q.16 State the criteria on the basis of which CO_2, Rubisco and RuBP are interrelated. 1

2.4 Detects error and rectifies the same:

Q.17 Rewrite the following statement correcting the error, if any.

"Six molecules of RuBP react with 6 molecules 1 of carbondioxide to produce 6 molecules of PGA".

2.5 Compares:

Q.18 Give four differences between 'reduction of PGA during Calvin cycle' and 'oxidation of PGAl during glycolysis. 2

2.6 Classifies:

Organise the following substances under the categories,

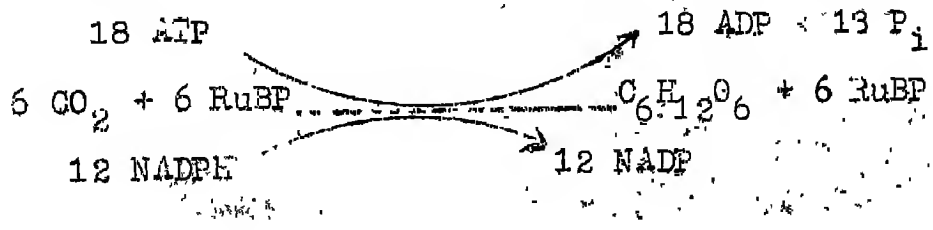
(a) products of light reaction, and

(b) products of Calvin cycle.

NADPH, NADP, ATP, ADP, O_2, PGAl. 1

2.7 Interprets:

Q.20 What does the following equation demonstrate with regard to Calvin cycle of photosynthesis?



4

2.8 Explains:

Q.21 Explain how PGA is reduced to triose phosphate involving the intermediate steps. 2

2.9 Extrapolates:

Q.22 How does Calvin cycle help in the purification of our environment? 1

Q.23 Mention the significance of Calvin cycle in the context of the environmental pollution. 2

3.0 APPLICATION:

Applies knowledge and understanding of the various content elements in unfamiliar situations.

Question Numbers 24 to 30 are based on the following experimental data.

In an experiment, three similar sets of algal cells marked A, B and C were fed with $^{14}CO_2$ for 5, 10 and 60 seconds respectively. On testing the compounds for radioactivity, the following observations were recorded:

Set-A: Only C_1 of PGA was radioactive; no other compound had radioactive carbon.

Set-B: Only C_1 of PGA and PGAL were radioactive.

Set-C: All three carbons of PGA and PGAL were radioactive; Also RuBP, glucose, glucose 1,6 diphosphate, and other intermediates were radioactive.

3.1 Analysis:

Q.24, Which of the carbons of PGA belongs to CO_2 ? 1

Q.25 State the fact which provides an important clue about the compound that reacts with CO_2 to produce PGA. 1

3.2 Makes hypothesis:

Q.26 Make a hypothesis to explain the presence of radioactive RuBP in Set-C. 1

3.3 Establishes relationship:

Q.27 How C_2 and C_3 of PGA become radioactive? 1

3.4 Gives reason:

Q.28 Why do the C_2 and C_3 of PGA in set-A remain non-radioactive? 1

3.5 Infers/Generalises:

Q.29 What conclusions can be drawn from the observation in set-A of this experiment? 1

3.6 Predicts:

Q.30 Where do the C_2 and C_3 of PGA come from ? 2

3.7 Judges:

Q.31 Which of the following statements presents the most acceptable hypothesis to explain how

do the radioactive carbons appear in RuBP on exposure of algal cells to $^{14}CO_2$ for 60 seconds?

A. $^{14}CO_2$ reacts with some organic compound to produce radioactive RuBP.

B. Glucose 1,6 diphosphate with radioactive C_1 reacts with $^{14}CO_2$ to produce radioactive RuBP.

*C. PGAl with radioactive C_1 regenerates radioactive RuBP through a series of reactions.

D. PGAl with radioactive C_1 regenerates radioactive RuBP after reacting with $^{14}CO_2$. 1

Q.3 Develops a unique communication/alternative experimental procedure:

Q.32 Develop a report of the experimental findings in about 150 words. 4

IV.

ILLUSTRATIVE QUESTIONS SAMPLING THE PROCESS OF REPRODUCTION:

Objective and specification-wise questions are given here to illustrate the meaning of these objectives and specifications categorised under the cognitive domain. The content area chosen for this purpose is "Animal Reproduction" prescribed for class XI/XII.

1.0 KNOWLEDGE:

Knows terms, definitions, facts, events, trends, sequences, procedures, concepts, principles, theories, generalisation, etc.

1.1 Recall/recognise term and definition:

Q.1. Sometimes the body of a single celled organism divides into more than one new organism by a process called

A. budding.

B. fission.

C. cogenesis.

D. segmentation. 1

Q.2. Mention the term used when a single celled body of an organism divides into many daughter organisms? 1

Q.3 Name the term which is used to represent the union between two dissimilar gametes. 1

Q.4. Mention the term used to represent the process by which unfertilized eggs develop into adults. 1

Q.5 Define the term 'fission' in relation with animal reproduction. Give two example of animal having this type of reproduction. 2

1.2 Recalls/recognises facts and events:

Q.6. Male and female organisms of the animal species produce cells specialised for sexual reproduction. These are called

A. morula

B. spores

C. zygotes

*D. gametes 1

Q.7 Name the product of fusion of sperm and ovum. 1

1.3 Recalls/recognises trends and sequences:

Q.8 Which of the following in the correct sequence of ducts to passon sperms from the testes to the outside in the male reproductive system of mammals ?

A. Epididymis, vasdeferens, urethera, ejaculating duct.

*B. Epididymis, vasdeferens, ejaculating duct, urethera.

C. vasdeferens, epididymis, urethera, ejaculating duct.

D. vasdeferens, ejaculating duct, epididymis urthera. 1

Q.9 Name the four stages sequentially which occur during the process of spermatogenesis. 1

Q.10 State any four important differences between the process of oogensis and spermatogensis. 2

Q.11 Describe in about 100 words the process of oogenesis in human female giving the various steps sequentially. 4

1.4 Recalls/recognises criteria, categories and classification:

Q.12 Isogamous sexual reproduction involves union of two

A. flagellate gametes.

B. non-flagellate gametes.

*C. similar gametes.

D. dissimilar gametes. 1

Q.13 On what basis you divide gametes into isogamy and anisogamy? 2

Q.14 Describe in 100 words about the four different types of reproduction processes in animals. No diagram is required. 4

1.5 Recalls/Recognises procedures:

Q.15 Which of the following steps represents the process of budding in Hydra?

* A. Proliferation and differentiation of some ordinary vegetative cells.

B. Modification and enlargement of some ordinary vegetative cells.

C. Proliferation and meiotic cells division of vegetative cells.

D. Meiotic cell division and Differentiation of vegetative cells. 1

Q.16 How the process of binary fission takes place in Amoeba? No diagram is required. 2

1.6 Recalls/Recognises Concepts and Principles:

Q.17 To produce ova in a human female is the function of

A. testis.

B. kidney.

* C. ovary.

D. oviduct. 1

Q.18 Name the organ which produces sperms in male human. 1

Q.19 Describe how fallopian tubes functions to transport ovum in the uterus. 2

Q.20 State how the bud grows externally on the surface of the body wall in Hydra. 2

1.7 Recalls/Recognises theories, generalisations or patterns:

Q.21 Which of the following statements represents the over all function of reproduction?

A. Reproduction maintains the survival of the individual.

*B. Reproduction maintains the continuity of the species.

C. Reproduction helps in the normal growth of the individual.

D. Reproduction helps in the normal growth of the species. 1

Q.22 Name the process which is associated with continuity of the species. 1

2.0 UNDERSTANDING

Understands terms, definitions, facts, procedures, concepts, principles, etc.

2.1 Translates (Also draws and labels/calculates)

Q.23 The cyclic changes in the reproductive track of the human female is described as

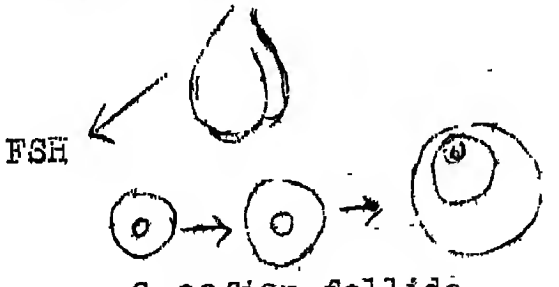
A. Menopause cycle.

B. Menstruation cycle.

C. Maturation cycle.

D. Malnutrition cycle. 1

Q.24 Pituitary gland



Graafian follide

What does the above diagram demonstrate? 1

Q.25 Draw a neat labelled diagrams showing binary fission in Amoeba. 2

Q.26 Draw neat labelled diagram of Oogenesis in mammals.

2.2 Cites examples:

Q.27 Name the hormone which maintains the corpus luteum.

Q.28 Which of the following is an example of sex hormone?

*A. Testosterone

B. Thyroxine

C. Adrenaline

D. Oxytocine

2.3 Identifies Relationship:

Q.29 During Oogenesis, the primary oocyte undergoes Meiosis-I to produce 1

A. two secondary oocytes of equal size.

*B. one secondary oocyte and one polar body.

C. one secondary oocyte and three polar bodies.

D. two secondary oocytes and two polar bodies.

Q.30 Name the hormone which is related with secondary sexual characters in human males. 1

2.4 Detects error

Q.31 Which one of the following is NOT the part of female reproductive system?

A. Uterus

B. Urethra

C. Fallopian tube

*D. Epididymis

primate males." Find the error in the statement and correct it. Rewrite it. 1

2.5 Compares:

Q.33 One common feature in human spermatogenesis and Oogenesis is that the primary gametocyte produces 1

A. diploid secondary gametocytes by Mitosis-I.

B. haploid secondary gametocyte by Mitosis-II.

*C. haploid secondary gametocyte by Meiosis-I.

D. diploid secondary gametocyte by Meiosis-I.

2.6 Classifies:

Q.34 Which of the following sets of substances comes under sex hormones?

*A. Testosterone, estrogen, progesterone

B. Testosterone, estrogen, thyroxine

C. Testosterone, progesterone, thyroxine

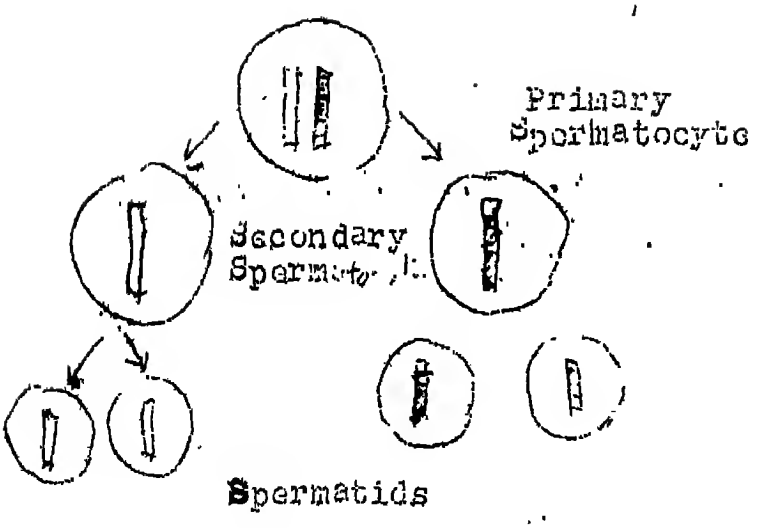
D. Testosterone, thyroxine, pitutrin 1

Q.35 Organise the following hormones into male and female sex hormones.

Estrogen, testosterone, progesterone 1

2.7 Interprets:

Q.36 What does the following diagram demonstrates with regard to nuclear division during spermatogenesis?



2.8 Explains

Q.37 The tests lie outside the body because for spermatogenesis, it requires

*A. lower temperature.

B. higher temperature.

C. Light.

D. fresh air. 1

Q.38 Failure of testis to descend into scrotal sac produces sterility. Explain why? 2

Q.39 Explain why only one single large ovum is formed from one primary oocyte after the completion of oogenesis.

2.9 Extrapolates

Q.40 To avoid the abortion in human female which of the following hormones will be advised to take by injection ?

A. Estrogen

B. Prolactin

*C. Progesterone

3.0 APPLICATION

Applies knowledge and understanding of the various content elements in unfamiliar situations.

The following sets were prepared in an experiment. Study them carefully to answer the question Nos. 41 to 51.

A	B	C	D	E
60°C + Pepsinogen + HCl + Milk	25°C + Pepsin + HCl + Milk	28°C + Pepsinogen + Milk	0°C + Pepsinogen + HCl + Milk	25°C + Pepsinogen + HCl + Milk

3.1 Analysesi

Q.41. In which of those sets of test tubes digestion process will be taking place?

A. A+B

B. B+C

C. B+D

*D. B+E 1

Q.42 Which one of the test tubes will be acting as control experiment in relation with principle of digestion. (Ans. Tube E) 1

3.2 Makes hypothesisi

Q.43 Which one of the following hypothesos best explains that why food was not digested in

A. At low temperature HCl was freezed so it could not act over the enzyme.

B. At low temperature milk was freezed so there was no action of enzyme.

C. At low temperature enzyme get hydrolysed and so no action of enzyme takes place.

* D. At low temperature conversion of pepsinogen into pepsin does not take place, so no enzyme action. 1

3.3 Establishes relationship:

Q.44 The 'A' test tube was kept for a time being in cold water and it was observed that it also shows the process of digestion. This shows that enzyme reaction is dependent on

*A. temperature of the medium

B. quantity of enzyme.

C. quantity of food.

D. temperature of the food. 1

Q.45 Which two test tubes in this experiment can be used to show the effect of temperature on digestion by checking the process of digestion? (Ans. B & E) 1

3.4 Gives reasons :

Q.46 Why in test tube 'A' digestion is not taking place when all the things required for digestion are present?

B. Medium is not suitable for enzymatic action.

C. Substrate is not suitable for enzymatic action.

D. Enzyme is not suitable for digestion. 1

Q.47 State the fact why 'E' test tube is acting as control experimental tube and not the 'B'. 2

Q.48 Which of the following statements is in accordance with the principles of enzyme action in the above experiment?

A. Enzymes require proper temperature and medium to work.

B. Enzymes require proper temperature and substrate to work.

*C. Enzymes require proper temperature, medium, and substrate to work.

D. Enzymes require proper temperature, medium and container to work. 1

Q.49 What will be the fate of test tube 'D' if temperature is raised to 25°C and milk is changed to starch? 1

A. Digestion will take place.

*B. Digestion will not take place.

C. Starch will be destroyed.

D. HCl will breakdown into H^+ and Cl

3.7 Judges

Q.50 In 'D' test tube temperature is raised to 28°C and HCl is exchanged with H_2SO_4.

the following statements will be in corresponding to the happening taking place in test tube 'D'?

A. Moderate temperature will promote the process of digestion and acid has no effect.

B. Moderate temperature will not promote the process of digestion but acid will be effective.

C. Moderate temperature will promote the process of digestion and acid will also be effective.

D. Moderate temperature will not promote the process of digestion and acid has no effect. 1

3.8 Suggest alternative procedure :

Q.51 Which of the following experiments will be alternative experiment to show that digestion required proper temperature, medium and substrate ?

*A. 25°C + Trypsinogen + pH 6 + Mutton

B. 25°C + Trypsinogen + pH6 + Milk

C. 0°C + Trypsin + pH3 + Mutton

D. 60°C + pH4 + Trypsin + Milk

V.

ILLUSTRATIVE QUESTIONS SAMPLING THE CONCEPT OF POPULATION

Objective and specification-wise questions of various forms are listed here in order to specify the meaning of these objectives and specifications categorised under the "Cognitive Domain". The subject matter has been sampled from the "Concept of population and Species".

1.0 KNOWLEDGE:

Knows terms, difinitions, facts, procedures, concepts, principles, generalisations, etc.

1.1 Recalls/Recognises terms and definitions:

Q.1. Honey bees having several forms of individuals can be termed as

A. Monomorphic

B. dimorphic

C bimorphic

*D. polymorphic 1

Q.2. Mention the term used for the occurrence of two forms among the organism of same kind. 1

Q.3. Define dimorphism. 1

1.2 Recalls/recognises facts

Q.4. Name the most concrete and easily observable unit of organisation. 1

Q.5. Mention any two important reasons why man has become the dominant species in the Biosphse 2

1.3 Recalls/Recognises trends and sequences.

Q.6 The sequence of hierarchial level of :

(1) individual (2) species and (3) population

is correctly represented by

A. 1 → 2 → 3

B. 3 → 2 → 1

*C. 1 → 3 → 2

D. 2 → 3 → 1

Q.7 The correct sequence of formation levels of organisation in an increasing order of complexity is

A. Cells → Organs → Tissues

* B. Cells → tissues → organs.

C. Organs → tissues → Cells

D. tissues → organs → cells

1.4 Recalls/recognises criteria, categories and classifications:

Q.8 Write the four attributes which enable us to define a species.

1.5 Recalls/recognises procedures:

Q.9 Express mathematically the relationship between population density and number of individuals case of aquatic organisms.

1.6 Recalls/recognises concepts and Principles.

Q.10 Enunciate the concept of population and species.

Q.11 Man has been using material and energy from the environment, more than any other species for what purposes? Mention any four of them.

1.7 Recalls/recognises theories and generalizations:

Q.12. In a forest plant and animal species live together and fulfil their requirements from each other. This represents

A. continuity of species.

* B. interdependence of life.

C. balance in nature

D. dominance of plant populations.

2.0 UNDERSTANDING

Understands terms, facts, concepts, principles, generalisation, etc.

2.1 Translates:

Q.13 In an aquatic cistern filled with $5m^3$ of water, 75 Azolla plants have been counted. What would be the density of their population?

Q.14 Draw a labelled diagram showing the interrelation between individuals, populations and species.

2.2 Cites examples:

Q.15 Name a commonly occuring tree showing sexual dimorphism.

Q.16 Name the most important boundary between different species.

2.3 Identifies relationship

Q.17 State how population is related to species? 1

Q.18 The delicate ecological balance in nature has been disturbed by man. Mention any two human activities related to it. 2

Q.19 Differences in structure and function in individual members of the same species depend upon certain features. Mention any four of them. 4

2.4 Detects error:

Q.20 Which of the following is a correct statement?

A. Individuals growing in Zone of overlap of two species are sterile.

*B. Individuals growing in zone of overlap of two species are more vigorous.

C. Individuals growing in home range of a species are more vigorous.

D. Individuals growing in home range of a species are slow growing. 1

2.5 Compares:

Q.21 A polymorphic species differs from a dimorphic species in having 1

A. one form of individuals as against two.

B. two forms of individuals as against three.

C. two forms of individuals as against four.

*D. several forms of individuals as against two.

2.6 Classifies

Q.22 Honey bees, ants belong to polymorphic type; which one of the following belongs to dimorphi type?

A. Butter-flies.

B. Moths

*C. Lion

D. Termites

2.7 Interprets:

Q.23 In the calvin cycle RuBP is the accepter of carbon dioxide but it is not consumed. What does it mean? 1

2.8 Explains:

Q.24 Inter specific breeding in nature is NOT prevented by

(1) reproductive isolation

(2) geographical isolation

(3) habits of individuals

* (4) similarity among incividuals. 1

Q.25 Explain any two purposes for which conservation of environment is to be made.

2.9 Extrapolates

Q.26 In captivity, the mallard duck and the pintail duck breed to produce fertile offsprings. But in nature, although they live in the same place, even then they do not interbreed. Why?

Q.27. If the reproductive isolation between the two different species is removed, what would be its outcome?

3.0 APPLICATION

Applies knowledge and understanding of various content elements in unfamiliar situations.

3.1 Analyses:

Q.28. Members of different populations of an entomophilous species occurring in mountain areas are discovered not to interbreed with those found in areas having recently built lime kilns. How does it happen? Explain.

3.2 Q.29 Members of different populations of an entomophilous species occuring in mountain areas are discovered not to interbreed. Which of the following reasons best explain this?

A. The populations are growing on two different and distant slopes of mountains.

B. They are separated by a large lake.

* C. The pollinator might have disappeared from some areas.

D. The populations have slightly different flowering seasons.

3.3 Establishes relationship:

Q.30 Members of different populations of an entomophilous species occurring in mountain areas are

areas having recently built lime kilns. How are the two related? 2

3.4 Gives reasons:

Q.31. Members of different populations of an entomophilous species occurring in different areas in and around Nainital are discovered not to interbreed. Mention the possible reasons. 2

3.5 Infers/Generalises:

Q.32 Members of different population of an entomophilous species occurring in mountain areas are discovered not to interbreed with those found in the areas recently built lime-kilns. What conclusions can be drawn from this situation? 2

3.6 Predicts:

Q.33 Members of different population of an entomophilous species occurring in mountain areas are discovered not to interbreed with those found in the areas having recent built lime kilns what would be the future to these plants and why? 2

3.7 Judges:

Q.34. The members of different population of an entomophilous species occurring in mountain areas are found not to interbreed with those found in areas having recently built lime kilns. Evaluate which of the following statements best

A. Populations under reference are growing on different and distant slopes of mountains.

B. Populations under reference are separated by large lake.

*C. Pollinators might have disappeared from these areas.

D. Populations under reference have difference in flowering seasons.

5.8 Suggests an alternative procedure:

Q.35 Members of different populations of an entomophilous species occurring in mountain areas are discovered not to interbreed with those found in areas having lime kilns. Which of the following steps will be appropriate to remove this situation?

A. More water be provided to these plants

B. Fallout from lime kilns be checked.

C. Lime kilns be removed from the mountain areas.

*D. Lime kilns be closed during flowering season.

APPENDIX-A.

LIST OF PARTICIPANTS OF THE WORKSHOP ENTITLED, "DEVELOPMENT OF ILLUSTRATIVE QUESTIONS FOR TESTING VARIOUS SPECIFICATIONS OF THE INSTRUCTIONAL OBJECTIVES IN PHYSICS, CHEMISTRY AND BIOLOGY" HELD AT N.C.E.R.T., NEW DELHI w.e.f. 22.1.1990 TO 25.1.1990

S.No.	Name and Address of Participants.
1.	Dr. K.K. Tiwari Addl. Director, Academic Staff College, R.D.V.V. Jabalpur.
* 2.	Shri J.C. Sharma, P.G.T. Biology, Govt. Boys Sr.Sec. School, Naraina, New Delhi.
* 3.	Mrs.Usha Lamba, Sr. Science Counsellor, Office Incharge, Science Centre, Hakikat Nagar Delhi-9.
* 4.	Shri Virendra Srivastava, Principal, Govt. Model Co-Ed. Sr.Sec. School, Raj Niwas Marg, Delhi.
5.	Shri B.K. Bhadri, P.G.T. (Phy.) K.V.K.M. Road, New Delhi.
6.	Shri S K Suri, Head, Chem. Department N.D.M.C. Navayug School Lajpat Nagar, New Delhi-23.
7.	Dr. Indra Prakash, Reader, Deptt. of Education (C.I.E.) Delhi University, Delhi-7.
8.	Dr. P.K. Ahluwalia, Lecturer in Physics, Physics Department, H.P. University, Shimla-5.
9.	Shri Rajinder P. Sharma, Lecturer in Physics, G.S.S.S. Bashehra, Distt. Una (H.P.).
10.	Dr. J.N. Mohanty, Reader in Physics Ravenshaw College, Cuttack-753003.
* 11.	Dr. S. Bhargava, Lecturer, Govt. College, Ajmer.
12.	Mr. K.V. Rama Sastri, Head of the Deptt. D.N.R. College, Bhimavaram (A.P.)

S.No. Name and address of participants.

13. Mrs. Talat Aziz,
Reader, Deptt. of Teacher Training,
Jamia, Millia Islamia,
New Delhi.

14. Mr. Madhu Mehrotra,
P.G.T.(Chem.)
K.V.N.M.Road,
New Delhi-67.

15. Mr. P.K.Chadha,
K.V.N.M. Road,
J.N.U., New Delhi.

* 16. Dr. Shiva Sharma,
Associate Prof.,
Deptt. of Botony,
University of Jaipur

* 17. Dr. R.L.Gupta
Prof. in Botany,
Govt. Sec. College,
Gwalior.

18. Prof. S.R.Chaudhary,
Deptt. of Physics,
Delhi University,
Delhi-7.

Note: * indicates the names of experts worked in the Biology group.

APPENDIX-B.

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